nearly pure silica; so also are the minute barbs upon the awns; and the short bristles on the surface of the ovaries in Erodium resemble, in miniature, the spiny bones in the dorsal fin of a perch.

Other bearded or barbed-seeded or rough-burred plants have increased in several places within the region referred to in this paper, among these are the burr-clover (*Medicago denticulata*) and the thistles (*Centaurea melitensis* L., and *C. solstialis* L.), both introduced species; the barley-grass, however, has the advantage over all others and is likely to maintain it.

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A SPECULATION ON PROTOPLASM.

BY PERSIFOR FRAZER, JR.

THE researches of comparative anatomists in late years have thrown much light upon the mode of development of the germ or embryo to the adult form of the species from which it is derived, and by the labors of Haeckel, Huxley, Cope, and others, much encouragement has been offered to the hope that man will yet push his knowledge of the processes of the development of life at least so far into their infinitesimal beginnings that the highest powers of the microscope and the most delicate appliances of physical science can no longer aid him. In this gradual triumph over what at first seemed insurmountable difficulties, many lines of interesting speculation are opened up, which, though lacking the permanent value of demonstration, are not without a certain use.

One of these is connected with the material out of which these wonderful structures are built; a material seeming to form the common point of intersection of all lines of organisms. For the latter, though widely separated in their several states of perfect development, when traced towards their origin, exhibit more and more striking resemblances and analogies; and they consist of a common substance, namely, the ultimately structureless (or amorphous as it is sometimes perhaps too hastily called) protoplasm or sarcode.

This wonderful substance which composes the simple cell of plant and animal, is capable of a distinct and individual life, and its methods of growth and multiplication (or rather division) have been beautifully demonstrated by many eminent naturalists. And wherever the phases of this chameleon may be observed, each is the easily recognizable child of all it has passed, and the common parent of all beyond and above it, howsoever divergent may be the path. But it is the vulgar error to misunderstand this analogy (as in the relations of man and monkey, etc.) when criticizing the doctrine of evolution. For only on the trunk do all divergent forms unite. No *bough* is parent to another, but they are brothers of the same parent stem.

This ultimate organic matter, or common building material, if not identical in chemical composition, is at least always composed in the main of the same few elements.

Robin's composition of the amniotic fluid of a fecundated ovum[1] contains:

	Per thousand.
1. Water	991.00 to 975.00
2. Albumen and mucosine	0.82 to 10.77
3. Urea	2.00 to 3.50
4. Creatine and creatinine	not estimated.
5. Sodium lactate	trace.
6. Fatty matters	0.13 to 1.25
7. Glucose	not estimated.
8. Potassium and sodium chlorides	2.40 to 5.95
9. Calcium chloride	trace.
10. Sodium carbonate	trace.
11. Sodium sulphate	trace.
12. Potassium sulphate	trace.
13. Calcium and magnesium	trace.
14. Phosphates and sulphates	1.14 to 1.72
Sum	997.49 to 998.18
Leaving undetermined, and to be divided between creatine, creatinine, sodium lactate, glucose, chlorides, sulphates, etc., and loss	2.51 to 1.81

This analysis does not, it is true, represent protoplasm from the simplest structures, but that which is used in organic edifices of a relatively high state of complexity; nevertheless the table is valuable as showing that despite the very heterogeneous nature

[1] See Flint's Text-book of Physiology, p. 903.

of this fluid, the number of elements which essentially compose it is few, thus:

Water	H_2O	
Albumen	C, H, N, O, S, slight variations in composition. Molecule not known.	
Mucin	$C_a H_b N_c O_d$ variable.	
Urea	$NH_4(CN)$	
Creatine	$C_4H_9N_3O_2$	
Creatinine	$C_4H_7N_3O_2$	
Sodium lactate	$Na_2(C_3H_4O_3)$	
Fatty matters	$C_a H_b O_c$	0.013 to 0.12 p. c. per thousand.
Glucose	$C_6H_{12}O_6$	
Mineral salts	KCl $NaCl$ $CaCl_2$ Na_2CO_3 Na_2SO_4 K_2SO_4	traces.
Magnesian and calcareous phosphates & sulphates	$Mg_3(PO_4)_2$ $Ca_3(PO_4)_2$ $MgSO_4$, $CaSO_4$	0.11 to 0.17 p. c.

By glancing at the above tables it will be seen that the bulk of this fluid is made up of the type elements H^{I} O^{II} N^{III} C^{IV}, and these are *essential*, while sulphur, sodium, potassium, chlorine, magnesium, calcium and phosphorus are more or less accidental, or at least make up but a small part of its substance (*i. e.*, 0.4 to 1 p. c. at the highest estimate).

Even here, then, in a highly complex animal fluid, one about to commence the architecture of the various parts of one of the most complex animals in nature—man; the bricks, though most diverse in form, color and durability, are almost altogether composed of the same four simple substances which make the waters, the atmosphere and the plants, viz: C N O H.

But this conformity to rule, which would make these elements the only four necessary constituents of organisms, though close, is not exact. Sulphur always occurs, though in small and varying quantity. Phosphorus is generally present as an inorganic compound.

Nor is it known, (1) how greatly this material may vary in constitution and still subserve the needs of the growing thing which assimilates it; (2) how greatly the needs themselves of a race of growing things may alter with gradually changing circumstances. Has it always been necessary to build living things out of three combustibles and a diluent? When one attempts to speculate upon the *possible* answers to these now unanswerable questions, the difficulties crowd thick upon him. In the early history of the universe (or better, of our own planetary family) was it possible for living beings to exist? What constitutes a living being? Some physiologists hold nutrition and reproduc-

tion to be the necessary concomitants of life. Others reject the latter on the ground that animals, like the working bees and the sterile ants, not to speak of the hybrids, do not fulfill it.

All seem to agree that life is a manifestation of force, but so is crystallization. Crystallization, or inorganic life, however, seems to differ from organic life in this, that the ultimate components of the structure due to the latter are cells or irregularly-shaped sacs with or without skin, nucleus and nucleolus, and if this cell is broken up into parts it does not simply become two smaller but similar bodies, but either commences to disintegrate and fall to pieces or remains a broken and *dead* cell. In the former case the smallest constituent part yet reached is similar to, or at least connected by, rigid geometrical laws with the largest form in which it manifests itself.

By inductions based by mineralogical microscopists on the analogies in the behavior of matter in the magnetic field and in polarized light, it is rendered probable that each of the constituent molecules of a crystal is allied to the crystal itself in its form, and that both forms are due to what might be called stereo-polarity, or the interplay of several (*i. e.*, more than two) polar forces acting along different axes, which holds the molecules of solids together, and gives the latter their characteristie forms. The results would necessarily be the repetitions of the same form or of the crystallographic analogues of that form (*i. e.*, different derivations in the same crystal system) and the growth of monsters which are so often met with.

Supposing this definition then to stand, the difference between organic growth and crystal growth would be that in the one case the product is dissimilar, in the other similar to the component parts.[1]

But is a fundamental distinction reached here?

Is it possible that beyond the range of the microscope there are minute forms composing these cells which are each in itself geometrically regular, yet constituting in the aggregate an ungeometrical body as the starting point for life-building?

Considering molecules of matter as inert and acted upon simul-

[1] The curious effects produced by the twin structure of crystals, as for example the production of an apparently hexagonal crystal by the union of several which are rhombic (chrysoberyl, etc.), offers no exception to the rule since the analogy spoken of still exists between the rhombic (?) molecule and each twin.

taneously, but with different degrees of force in different directions, then if those similar molecules were distributed evenly in any menstruum, there would necessarily result such a grouping of them as to form definite geometrical figures, whether these forces were those of attraction or repulsion or both together. It is possible, but not proven, that the different atomicities or atom-saturating powers of different elements may be due to different numbers and positions of these magneto-polar axes. From the grossest to the smallest manifestation of growth force; from the long neck of the giraffe to the segmentation of the ovum, there is observable but the interaction of polar forces, producing results, however, which are most dissimilar. In such large masses as we can see, these are modified by each other, in great measure, so as to produce curves instead of straight lines, as the pendulum does when struck sideways during its plane oscillation; but a multiplicity of polar forces thus interacting will account for all the phenomena.

There is no ground for supposing that these forces so patent in masses large enough for us to observe, cease to act upon matter even when in the state of finest comminution. And if they do, the result of a concourse of molecules, whether of organic or of inorganic origin, under the direction of polar forces must produce geometrical form.

The only means of testing whether this is the case in these organic cells (since the bodies, if they do exist, must be too small to be capable of being seen under the most powerful microscope) is by the employment of a more delicate test than the recognition of form, and such a test is the modification of color by transmission through thin films of them. The waves of light in passing between the constituent atoms of a body, experience a retardation proportionate to the density of the medium; which is only saying proportionate to the mean distance of the atoms apart, which again is governed by the amount of the attractive force exerted in a given direction. Bodies in which the density is equal in all directions retard the passage of light equally in all directions, whereas if the density be different in different directions the retardation will be different also and a new phenomenon will result.

It is known that nearly all organic structures have the property of polarizing light, and hence are built up by the interaction of polar forces of different intensity, and if the first proposition

be correct, the establishment thus of the existence of several different independent lines of force renders the existence of a geometrically constructed organic unit at least probable.

Why these smallest organic molecules do not construct the perfected product on their own model, while the analogous crystalline molecules do, is a problem for future solution.

If the sarcode or protoplasm be susceptible of slight chemical changes, and in fact suffers such changes without losing the power to fulfill its function of repairing waste tissue, then in the progress of the decay of worlds, and the changes of external conditions consequent upon it, Darwin's law of survival must inevitably be felt where an accidental alteration of the substance of the sarcode and the resulting changes impressed upon the structure enabled one animal to live where others perished. The formation of more combustible compounds, and the increase of the capacity of alimentation, for instance, might balance the tendency of the atmosphere of a cooling earth to depress the temperature of the blood below the living point. But why should it only exert its recuperative energy in the direction of maintaining the present condition of things? An amount of plasticity equal to this need is quite capable of changing the conditions of life themselves, and instead of rendering it possible for *man* to exist with blood at 99° Fahr., in an arctic world; to manufacture of man and his terrestrial companions, beings to whom that temperature would be normal and salutary.

To a limited extent it seems as though we were justified in accepting a difference of this kind in our present organic nature. How else than by a sarcode of different chemical constitution are the physical differences of race to be accounted for? How, indeed, is evolution to be accounted for according to the Darwinian explanation?

And if the change to varieties is thus produced, why not to species, genera, families, groups, orders, classes, sub-kingdoms;—why is it not possible that the very kingdoms of life and the forms peculiar to them may be altered in this way to suit the gradually changing external conditions of nature? The prejudice in our minds against the possibility of any living thing existing on the surface of the sun is based upon various conditions there, which in our experience are inconsistent with life. Amongst others may be mentioned, that to the best of our knowledge, 1st,

the temperature is above the fusing point of platinum; there is no solid land that we know on which objects could stand, and if there were the weights of the bodies that we know would be so great at the surface of the sun that they would be crushed. That our feet would find no resting place, or if they did, our strength would be insufficient to bear up the tons which our bodies would then weigh, and even if this were not so, our C N O H bodies would be dissipated as gases. The reverse is the case in the cold cinders called asteroids. There the cold would instantly kill any living thing that we know.

But what is there to preclude the possibility of living things colder than frozen mercury, or hotter than molten platinum. In fact since the only manifestation of vitality we can know is the action of force upon matter, until these two components are obliterated, how can one predict the extinction of life?

This has some bearing on the ever recurring questions of immortality or existence after visible disintegration. But up to this point it has been assumed that the external conditions were being changed with extreme slowness. If only this obtained, there would seem to be no positive improbability of life in beings composed wholly of liquids or gases.

Of course it is to ridicule the subject to conceive a being whose epidermis of platinum resisted successfully the waste of oxidation even at the prevailing red heat, and whose stomach of porcelain would melt up the metallic silicates and send them coursing through wrought iron arteries to be assimilated into metallic or ceramic organs, and to pass through the usual stages of activity, decay, and re-utilization; while the siliceous brain and the asbestos nerves quivered with sensations of pleasure forever denied to us combustibles. Yet it is not too much to claim that no sufficient reason can be given for confining the material out of which sentient beings can be constructed to the four type elements above referred to; nor is there any reason apparent why a gradual change in the organs of assimilation as well as in the material assimilated should not accompany and compensate all gradual changes in the outside world, thus rendering the thread of life continuous through beings more diverse than any that we yet know.